RV LITTORINA L15-20

Cruise Report

01. – 07.08.2020

Chief Scientist:

Mareike Kampmeier
GEOMAR Helmholtz Centre for Ocean Research Kiel

1. Participants

Table 1: Scientific crew

Name	Function	Institution
Mareike Kampmeier	Chief Scientist	GEOMAR Helmholtz Centre for Ocean Research Kiel
José Felipe Barradas	Scientist	VLIZ*
Daniel Wehner	Scientist	EGEOS GmbH
** Flanders Marine Institute, Belgium*		

2. Objectives of the Cruise

The objective of the cruise was to locate dumped chemical and conventional munition in dumping grounds around Helgoland in the North Sea.

More specifically the objectives were:

- Mapping dumping grounds with high resolution multibeam (MBES) and identify munition locations on the seafloor
- Evaluating the MBES RESON SeaBat T50 *Extended Range* for enhanced munition detection
- Mapping munition locations with high resolution SBP to detect buried munition an create 3D datasets
- Taking water samples for TNT and chemical warfare (CW) analyses

3. Introduction

More than 1.6 million tons of chemical and conventional munition are remaining in German territorial waters. These are either unexploded ordnances (UXO) from direct war actions or dumped munitions after the war had ended. Even though locations of dumpsites are known, knowledge about their real extent underwater, exact positions and numbers of munitions is rather incomplete. Munitions in the sea are not only a risk for offshore industries, but also for fishery, coastal tourism, and marine food consumers. Whereby the risk of explosion is rated as rather low (apart from offshore construction sites), carcinogenic TNT is leaking out and is taken up by the marine environment (Beck et al., 2018; Strehse, Appel, Geist, Martin, & Maser, 2017). The effect of TNT and its metabolites inside the food chain is subject of ongoing research. Within the UDEMM project (2016-2019) methods for monitoring dumpsites have been developed and evaluated.

The BASTA (<u>B</u>oost <u>A</u>pplied munition detection through <u>S</u>mart data in<u>T</u>egration and <u>A</u>I workflows) project started in December 2019 and is funded by the European Maritime and Fisheries Fund (EMFF) of the European Union in the “Blue Labs” program. It aims for increasing the accuracy and cost-efficiency of munition detection methods on local and larger scale. Therefore, advanced data-acquisition such as ultra-high-resolution 3D sub-bottom profiling (SBP), intelligent autonomous underwater vehicle (AUV) based magnetic mapping will be combined with high-resolution multibeam mapping. A multi-sensor database enables sustainable use of survey data and automated data analysis.

During cruise L13-20, two dumpsites around Helgoland were targeted to be mapped with SBP, MBES and magnetics. Due to Corona regulations, and resulting restrictions on staff on board, the towed magnetic could not be performed. Since the GIRONA 500 AUVs from GEOMAR are not capable to work against tidal currents, no AUV for magnetic and optical data acquisition was taken on board.

4. Research Area

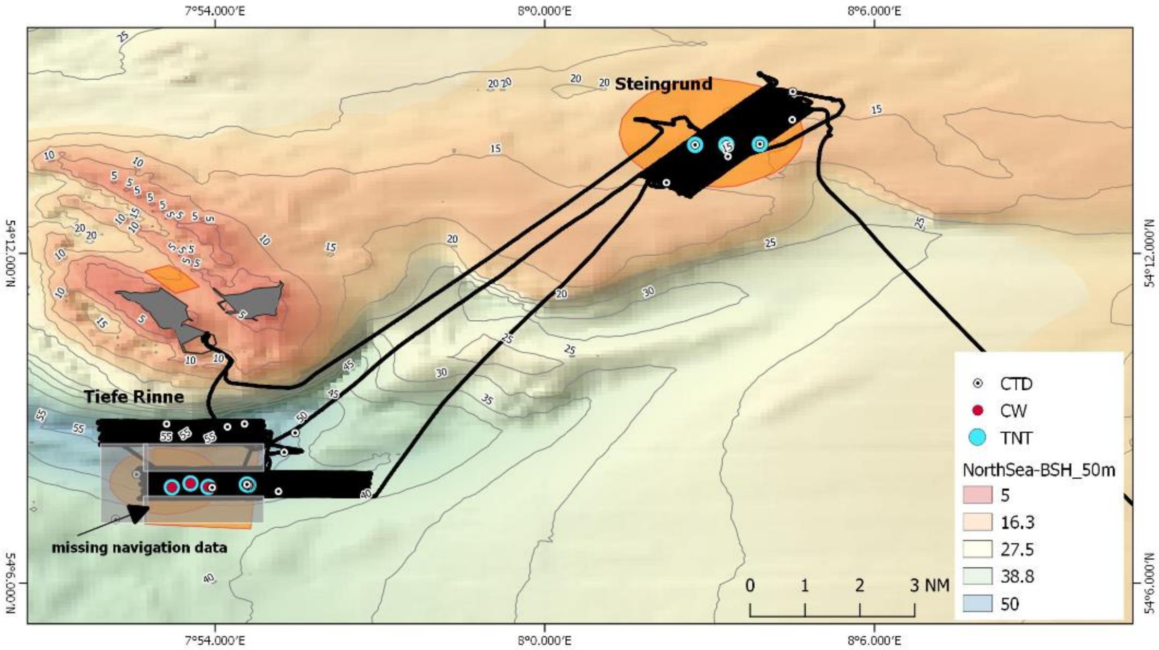

Figure 1: Overview map of the working area of cruise L15-20 with the two research areas Tiefe Rinne and Steingrund. The black line shows the cruise track and the orange areas indicate munition dumpsites.

Tiefe Rinne

The area 'Tiefe Rinne' is located 2 nmi south of Helgoland and is part of the former Elbe river mouth during the last glacial. It is characterized by a 57 m depression, also known as 'Helgoländer Loch'. Since 1945 this area has been marked as spoiled ground and indicated as munition dumping ground in nautical sea charts. According to research of the BLANO committee 'Arbeitskreis Munition im Meer', 6,000 10.5 cm artillery grenades containing the chemical warfare agent tabun were dumped here in 1949. They originally come from a train, which was bombed during WWII action in April 1945. The grenades were recovered and buried by the British Allied Forces in June 1945. In summer 1949, they were brought to Helgoland and dumped in 'Tiefe Rinne' (Böttcher et al., 2011). Even though surveys of the BSH and WTD71 were carried out in order to find the grenades, their location could still not be clearly determined.

10.5 cm artillery grenades are typically 30 cm long; 70 cm if the propellant charge is still attached and has a total mass of 13.7 and 15.4 kg and CWA volume of 1.5 l. The CWA Tabun acts as a nerve agent and is highly toxic. Since the status of the grenades is unknown and recovering bears the risk of contamination, it is thought to best leaving them on the seafloor. Nevertheless, risks and effects for fishermen and the local environment are still unknown and should be urgently studied.

During L15-20 a high resolution MBES and SBP were used to map the area. Points of suspicious objects were marked and resurveyed with very-high resolution.

Steingrund

The Natura 2000 site 'Steingrund' is located 6 nmi north-east of Helgoland and is characterized by a central SW-striking ridge. It is built up of glacial deposits (including rocks and boulders) and elevates from 15 to 8 m water depth. Within this area 5 depth charges have been found and dumping of Danish aerial bombs is suspected. Both munition types do not have a clear shape and it will be a challenge to distinguish them from rocks.

5. Methods and Devices

MBES

For high-resolution seafloor mapping, a RESON Seabat T50 Extended Range had been used on the ELAC pole on starboard side. This MBES was rented from the company MacArtney Germany and financed by the MELUND SH. It allows high-resolution data also in water depths more than 20 m, which is necessary to detect munition objects. The navigation done by two Septentrio DGPS antennas and supporting RTK via NTRIP. Motion correction was applied using the SBG Apogee motion sensor. Acquisition software was QinsY from QPS. The data are referenced to the geoid model GCG2005 and recorded as UTM32N.

Table 2: Specification RESON T50 Extended Range.

Frequency	400 kHz
Across-track beam width	0.5°
Along-track beam width	0.5°
Number of beams	10-1024
Swath angle	10-165°

SBP

The Innomar SES-2000 quattro multi-transducer SBP is owned by VLIZ and was mounted portside of FK LITTORINA. The Sub-bottom Profiling was deployed in Single Beam Mode (SBM) mode. In this configuration the four transducers combined to one square array and used simultaneously for transmiting and receiving. They ping with the maximum power available, using one ping for each cycle. In this way, you get one logical survey line per track (sailed line). This mode provides the best range/penetration range at the cost of survey efficiency.

There were recorded High Frecuency (HF) and Low Frecuency (LF) channels. The secundary frecuency (differential frecuency recorded) was 10 Khz for the whole survey, with a LF gain of 12 and 18 (depending of the area) and HF 12, 18 and 20. The depth penetration/recording was aimed to 4-5 m depth below the sea bed, and focused to UXOs detection.

Table 3: Specification INNOMAR SES-200.

Single beam mode	
PF source level / acoustic power	>245 dB / μPa re 1m / ~4 kW
Transmit beam width (-3 dB)	ca ±1.5° for all frequencies
Water depth range	1 – 500 m
Sediment penetration	up to 50 m*
Ping rate	up to 60 pings/s
Quad beam mode	
PF source level / acoustic power	>235 dB / μPa re 1m / ~2 kW
Transmit beam width (-3 dB)	ca ±2.5° for all frequencies
Water depth range	0.5 – 30 m
Sediment penetration	up to 20 m*
Ping rate	up to 15 pings/s per transducer

** Depending on sediment type and noise level*

TNT water sampling

At each station two water samples in two different heights were taken (surface and 2 m above seafloor). For each sample 1 l of seawater was filled into a urine bag and was spiked with 20 ml TNT solution. The sample was then hanged up and let drip through a resin filter. Once the water sampled was completely dripped through, the filter was wrapped in aluminium foil and stored inside a fridge (ca 6 °C).

CTD

Parallel to every water sample, a CTD profile was taken via a Sea and Sun Technologies CTD. It records pressure, temperature, conductivity and calculates resulting sound velocities. SRD files have been transformed to ASCII *.TOB files.

6. Cruise Narrative

Date	Time	Area	Action	Remark
2020-08-01	10:30:00	Kiel	Transit	
2020-08-01	20:00:00	Cuxhaven	Port	
2020-08-02	06:00:00	NorthSea	Transit	
2020-08-03	12:00:00	TiefeRinne	Mapping	
2020-08-04	13:10:00	TiefeRinne	Watersampling	
2020-08-04	14:15:00	TiefeRinne	Mapping	
2020-08-04	20:00:00	TiefeRinne	Watersampling	
2020-08-04	20:25:00	TiefeRinne	Mapping	
2020-08-04	21:00:00	Transit	Transit	
2020-08-04	22:15:00	Steingrund	Mapping	
2020-08-05	5:16:00	Transit	Transit	
2020-08-05	7:30:00	Helgoland	Port	
2020-08-05	17:00:00	Transit	Transit	
2020-08-05	18:30:00	Steingrund	Mapping	
2020-08-06	14:30:00	Steingrund	Watersampling	
2020-08-06	15:00:00	Steingrund	Mapping	
2020-08-07	0:00:00	Transit	Transit	
2020-08-07	3:00:00	Cuxhaven	Port	
2020-08-07	4:15:00	Transit	Transit	
2020-08-07	14:30:00	Kiel	Port	

7. Preliminary Results

During the cruise L15-20 ca 350 nmi of mapping profiles were achieved. Two research areas around Helgoland (Tiefe Rinne and Steingrund) were mapped with MBES and SBP (Figure 1).

Due to the water depth in the area ‘Tiefe Rinne’ of 45-57 m water depth and the resulting footprint of ca 200 m, profiling could be done with 100 and 80 m profile spacing. This resulted in full overlap for most of the profiles. During acquisition, locations of suspicious features were marked, but due to their size they cannot be clearly resolved within the MBES data. However, the area where most features were identified are consistent with results of previous mapping projects (WTD71). After full processing of the data, it will be possible to do a more sophisticated analysis of the data and compare it to the existing data set from 2010.

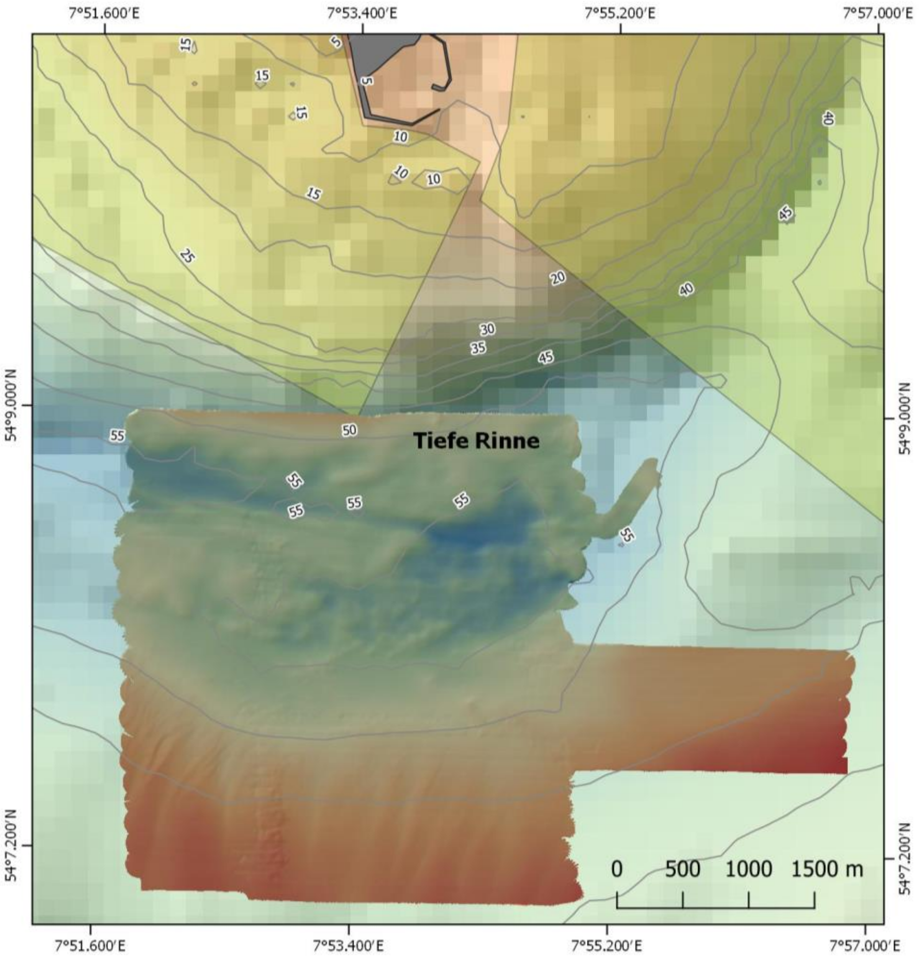

Figure 2: Bathymetric map of the research area 'Tiefe Rinne' south of Helgoland South Port. Maximum water depth of the channel is 57 m. The munition dumpsite area was mapped with MBES and SBP.

Water samples were taken in areas with highest feature density. At each station one surface sample for TNT plus one TNT and one CWA sample were taken 3 m above the bottom. For each station, a CTD was attached to the water sampling device, recording pressure, temperature and conductivity.

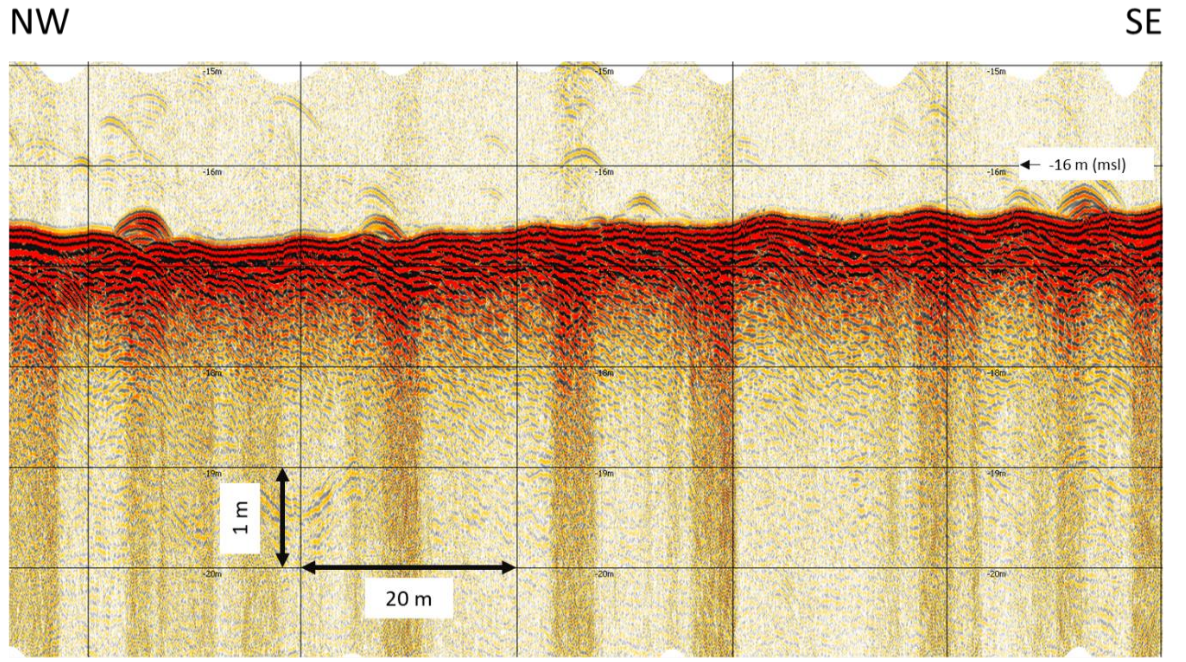

Figure 3: Few objects on the seabed. Profile 139. Single Beam Mode. Area: Steingrund. (L15-30_BASTA-3_20200804_234459_Q1).

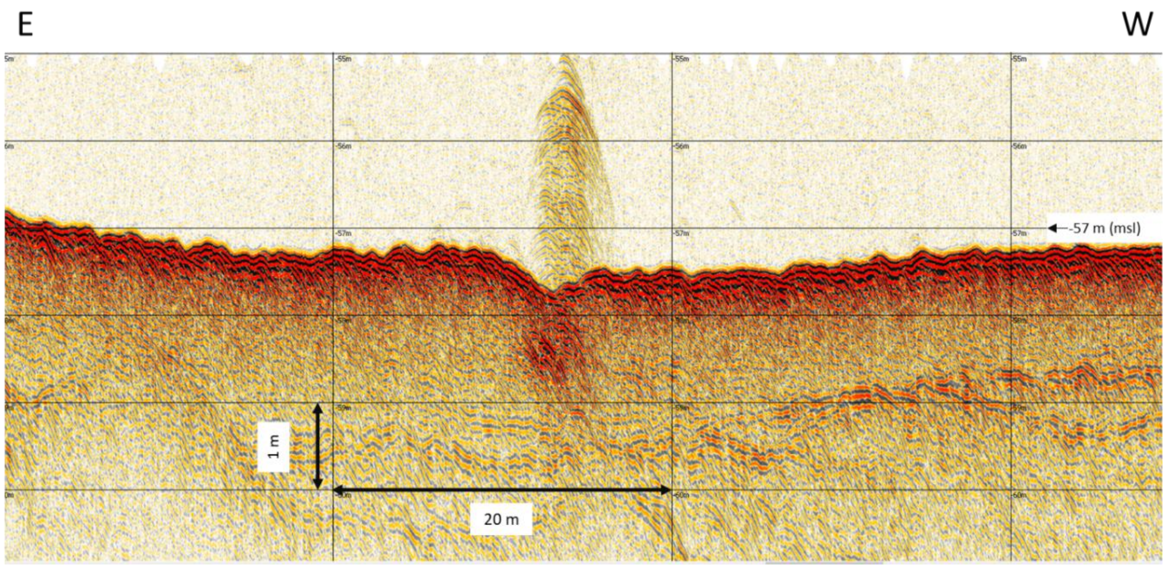

Figure 4: A feature buried in the seabed 1 m, and probably exposed. Profile 113. Single Beam Mode. Area: Tiefe Rinne. (L15-30_BASTA-3_20200804_091146_Q1)

Mapping in Steingrund took more time, as the profile spacing was 20 m to reach enough overlap. The area is characterized by very heterogenous seafloor. The central ridge is covered with rocks and boulders. The surrounding sediment shows extensive current ripples interspersed with an outcropping rocky facies and low amplitude (soft? No groundtruth available) sediments.

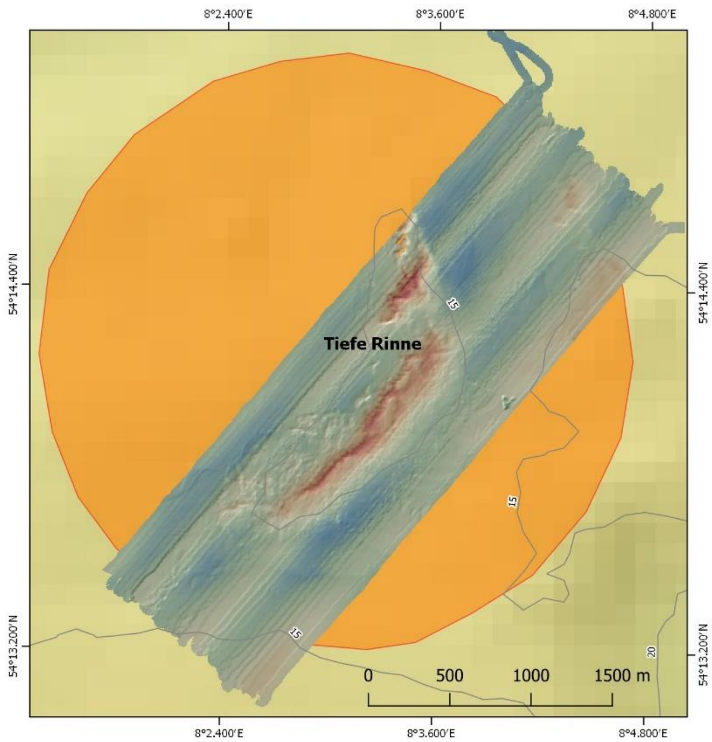

Figure 5: Bathymetric map of the research area 'Steingrund' north-east of Helgoland. The orange circle indicates the extent of the munition dumpsite area. The central part is dominated by a glacial ridge, which shows rocks and boulders on the surface.

Because the research area is so far offshore, the GSM signal coverage was low and RTK signal for height corrections failed several times during profiling. Raw navigation data was recorded for post processing. Also tide data has not been fully applied yet and need further post processing.

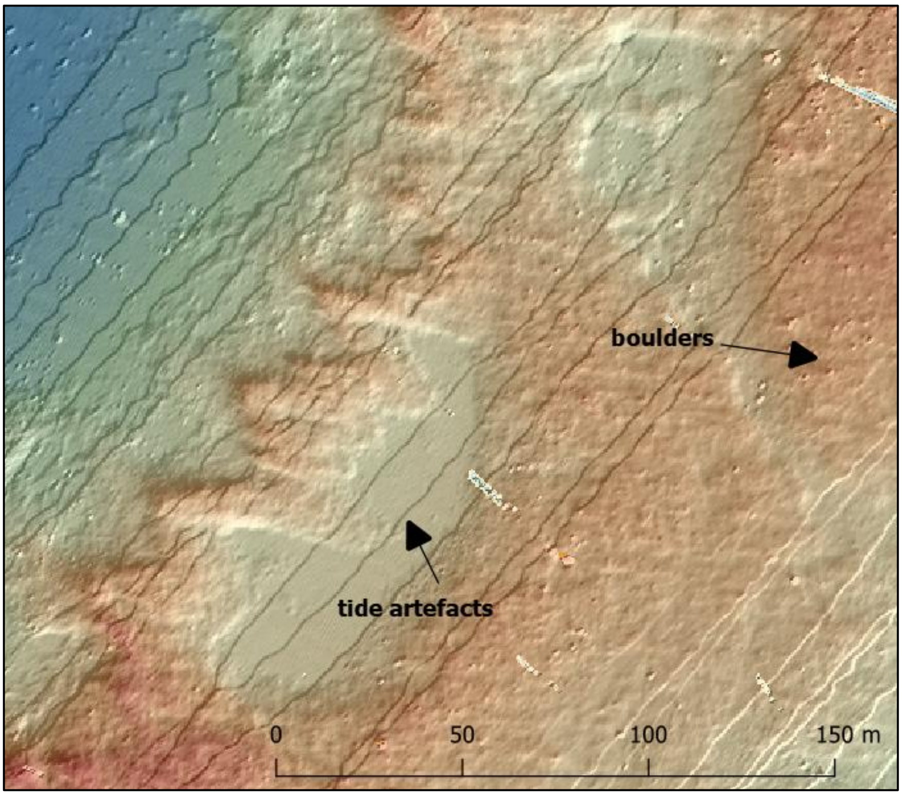

Figure 6: Close-up of the central part of the ridge in 'Steingrund'. The single MBES profile lines do not fully correlate yet, since tide data still needs to be adjusted. Nevertheless, the rough and uneven surface of the ridge is clearly distinguishable from the flat surrounding sediments.

8. Outlook

This cruise was the first cruise in these area within the BASTA project. Eventhough munition could not be clearly identified yet, the data is a good base for upcoming cruises. This time it was not possible to conduct magnetometer surveys, which should be definitely done in future. The MBES mapping helped to delimit a certain area within the dumpsite 'Tiefe Rinne', which can then be mapped with narrow profile spacing with a towed or AUV-based magnetometer.

9. Acknowledgements

Thanks goes to the crew and master of FK LITTORINA for the excellent cruise. We would also like to thank BRIESE RESEARCH for making research cruises possible, also in 'Corona-times'. The MBES and support were reliably done by MacArtney Germany. The cruise was performed as part of the European funded project BASTA ([863702] — [BASTA] — EMFF-2018-1.2.1.7).

10. References

Beck, A. J., Gledhill, M., Schlosser, C., Stamer, B., Böttcher, C., Sternheim, J., … Achterberg, E. P. (2018). Spread, Behavior, and Ecosystem Consequences of Conventional Munitions Compounds in Coastal Marine Waters. *Frontiers in Marine Science*, *5*(April), 1–26. https://doi.org/10.3389/fmars.2018.00141

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Strehse, J. S., Appel, D., Geist, C., Martin, H. J., & Maser, E. (2017). Biomonitoring of 2,4,6-trinitrotoluene and degradation products in the marine environment with transplanted blue mussels (M. edulis). *Toxicology*, *390*, 117–123. https://doi.org/10.1016/j.tox.2017.09.004

11. Appendix

I. Stationlist

Date	Time	Area	Action	Name	Remark
2020-08-01	10:30:00	Kiel	Transit		
2020-08-01	20:00:00	Cuxhaven	Port		set up SBP
2020-08-02	6:00:00	NorthSea	Transit		
2020-08-02	11:00:00	TiefeRinne	CTD	L15-20_CTD_SST_01	Sea and Sun CTD SN 453
2020-08-02	11:00:00	TiefeRinne	CTD	L15-20_CTD_VP_01	Valeport Mini Swift SN 56868
2020-08-03	12:00:00	TiefeRinne	Mapping		SBP+MBES
2020-08-03	19:15:00	TiefeRinne	CTD	L15-20_CTD_SST_02	Sea and Sun CTD SN 453
2020-08-03	19:15:00	TiefeRinne	CTD	L15-20_CTD_VP_02	Valeport Mini Swift SN 56868
2020-08-03		TiefeRinne	Mapping	ab L15-20_20200803-0001-0001	SBP+MBES; 120° swath, 600 beams, 360 kHz, 5.3 Hz ping rate;140 m range
2020-08-03		TiefeRinne	Mapping	L15-20_20200803-0048-0001 - L15-20_20200803-0051-0001	North-South profiles removed due to bad data quality (strong vessel motion)
2020-08-03	10:30:00	TiefeRinne	CTD	L15-20_CTD_VP_03	Valeport Mini Swift SN 56868
2020-08-03	10:45:00	TiefeRinne	Mapping	ab L15-20_20200803-0083-0001	SBP+MBES; High Res: 120° swath, 1024 beams, 360 kHz, 5.3 Hz ping rate;140 m range
2020-08-03	11:02:00	TiefeRinne	Mapping	S7k Daten recorded	
2020-08-03	15:04:00	TiefeRinne	Mapping	ab L15-20_20200803-0095-0001	SBP+MBES; High Res: 120° swath, 1024 beams, 280 kHz, 5.5 Hz ping rate;140 m range
2020-08-03	16:00:00	TiefeRinne	CTD	L15-20_CTD_SST_04	Sea and Sun CTD SN 453
2020-08-03	16:00:00	TiefeRinne	CTD	L15-20_CTD_VP_04	Valeport Mini Swift SN 56868

2020-08-03	19:40	TiefeRinne	Mapping	ab L15-20_20200803-0107-0001	MBES; High Res: 120° swath, 1024 beams, 200 kHz, 5.5 Hz ping rate;140 m range
2020-08-03	23:55:00	TiefeRinne	Mapping	ab L15-20_20200803-0119-0001	SBP+MBES; High Res: 60° swath, 600 beams, 360 kHz, 8.2 Hz ping rate;90 m range
2020-08-04	5:09:00	TiefeRinne	Mapping	ab L15-20_20200803-0134-0001	SBP+MBES; High Res: 60° swath, 1024 beams, 360 kHz, 8.2 Hz ping rate;90 m range
2020-08-04	9:50:00	TiefeRinne	CTD		Valeport Mini Swift SN 56868
2020-08-04	10:10:00	TiefeRinne	Mapping	ab L15-20_20200804-0146-0001	SBP+MBES; 120° swath, 600 beams, 360 kHz, 5.3 Hz ping rate;140 m range
2020-08-04	13:10:00	TiefeRinne	TNT	L15-20_TNT_01A	0 m
2020-08-04	13:10:00	TiefeRinne	TNT	L15-20_TNT_01B	20 m; 50 m waterdepth
2020-08-04	13:10:00	TiefeRinne	CW	L15-20_CW_01	20 m; 50 m waterdepth
2020-08-04	13:10:00	TiefeRinne	CTD	L15-20_CTD_SST_06	
2020-08-04	13:21:00	TiefeRinne	TNT	L15-20_TNT_02A	0 m
2020-08-04	13:21:00	TiefeRinne	TNT	L15-20_TNT_02B	20 m; 50 m waterdepth
2020-08-04	13:21:00	TiefeRinne	CW	L15-20_CW_02	20 m; 50 m waterdepth
2020-08-04	13:21:00	TiefeRinne	CTD	L15-20_CTD_SST_07	
2020-08-04	13:35:00	TiefeRinne	TNT	L15-20_TNT_03A	0 m
2020-08-04	13:35:00	TiefeRinne	TNT	L15-20_TNT_03B	20 m; 50 m waterdepth
2020-08-04	13:35:00	TiefeRinne	CW	L15-20_CW_03	20 m; 50 m waterdepth
2020-08-04	13:35:00	TiefeRinne	CTD	L15-20_CTD_SST_08	
2020-08-04	13:46:00	TiefeRinne	TNT	L15-20_TNT_04A	0 m
2020-08-04	13:46:00	TiefeRinne	TNT	L15-20_TNT_04B	20 m; 50 m waterdepth
2020-08-04	13:46:00	TiefeRinne	CW	L15-20_CW_04	20 m; 50 m waterdepth
2020-08-04	13:46:00	TiefeRinne	CTD	L15-20_CTD_SST_04	

2020-08-04	14:15:00	TiefeRinne	Mapping	ab L15-20_20200804-0151-0001	SBP+MBES; 120° swath, 600 beams, 360 kHz, 5.3 Hz ping rate;140 m range
2020-08-04	20:00:00	TiefeRinne	TNT	L15-20_TNT_05	
2020-08-04	20:00:00	TiefeRinne	CW	L15-20_CW_05	
2020-08-04	20:00:00	TiefeRinne	CTD	L15-20_CTD_SST_10	
2020-08-04	20:15:00	TiefeRinne	CW	L15-20_CW_06	
2020-08-04	20:15:00	TiefeRinne	CTD	L15-20_CTD_SST_11	
2020-08-04	20:25:00	TiefeRinne	Mapping	ab L15-20_20200804-0165-0001	SBP+MBES; 120° swath, 600 beams, 360 kHz, 5.3 Hz ping rate;140 m range
2020-08-04	21:00:00	Transit	Transit	L15-20_20200804-0166-0001	SBP+MBES; 120° swath, 600 beams, 360 kHz, 5.3 Hz ping rate;140 m range
2020-08-04	22:10:00	Steingrund	CTD		
2020-08-04	22:15:00	Steingrund	Mapping	L15-20_20200804-0167-0001	SBP+MBES; 120° swath, 600 beams, 360 kHz, 17.8 Hz ping rate;40 m range; use no geoid database
2020-08-05	4:00:00	Steingrund		L15-20_20200805-0179-0001	add offsets in database; waves increase 1.2m, bad data
2020-08-05	5:16:00	Transit	Transit		transit to Helgoland
2020-08-05	7:30:00	Helgoland	Port		
2020-08-05	17:00:00	Transit	Transit		transit to Steingrund
2020-08-05	18:00:00	Steingrund	CTD	L15-20_CTD_VP_12	
2020-08-05	18:00:00	Steingrund	CTD	L15-20_CTD_SST_12	
2020-08-05	18:30:00	Steingrund	Mapping	L15-20_20200805-0181-0001	Calibration; SBP+MBES; 140° swath, 600 beams, 360 kHz, 14.4 Hz ping rate;50 m range; use no geoid database

2020-08-06	0:30:00	Steingrund	Mapping	L15-20_20200805-0192-0001	lost RTK signal on the line; signal was recovered before next line
2020-08-06	3:20:00	Steingrund	Mapping	L15-20_20200805-0197-0001	lost RTK signal on the line; signal was recovered before next line
2020-08-06	6:30:00	Steingrund	Mapping	L15-20_20200805-0204-0001	lost RTK
2020-08-06	6:33:00	Steingrund	Mapping	L15-20_20200805-0205-0001	RTK back
2020-08-06	8:21:00	Steingrund	Mapping	L15-20_20200805-0209-0001	lost RTK
2020-08-06	8:40:00	Steingrund	Mapping	L15-20_20200805-0209-0001	RTK back
2020-08-06	13:15:30	Steingrund	Mapping	L15-20_20200805-0220-0001	lost RTK
2020-08-06	13:35:30	Steingrund	Mapping	L15-20_20200805-0220-0001	RTK back
2020-08-06	14:30:00	Steingrund	TNT	L15-20_TNT_06A	14m
2020-08-06	14:30:00	Steingrund	TNT	L15-20_TNT_06B	14m
2020-08-06	14:30:00	Steingrund	CTD	L15-20_CTD_SST_13	14m
2020-08-06	14:45:00	Steingrund	TNT	L15-20_TNT_07A	13m
2020-08-06	14:45:00	Steingrund	TNT	L15-20_TNT_07B	13m
2020-08-06	14:45:00	Steingrund	CTD	L15-20_CTD_SST_14	13m
2020-08-06	14:56:00	Steingrund	TNT	L15-20_TNT_08A	15m
2020-08-06	14:56:00	Steingrund	TNT	L15-20_TNT_08B	15m
2020-08-06	14:56:00	Steingrund	CTD	L15-20_CTD_SST_15	15m
2020-08-06	15:00:00	Steingrund	Mapping	L15-20_20200805-0223-0001	SBP+MBES; 120° swath, 600 beams, 360 kHz, 14.4 Hz ping rate;50 m range; use no geoid database
2020-08-06	18:54:00	Steingrund	CTD	L15-20_CTD_VP_16	
2020-08-06	15:00:00	Steingrund	Mapping	L15-20_20200805-0231-0001	SBP+MBES; 120° swath, 600 beams, 360 kHz, 14.4 Hz ping rate;50 m range; use no geoid database
2020-08-06	20:50:00	Steingrund	Mapping	L15-20_20200805-0235-0001	partly no RTK
2020-08-06	21:45:00	Steingrund	Mapping	L15-20_20200805-0237-0001	partly no RTK

2020-08-06	22:40:00	Steingrund	Mapping	L15-20_20200805-0239-0001	partly no RTK
2020-08-07	0:00:00	Transit	Transit		
2020-08-07	3:00:00	Cuxhaven	Port		
2020-08-07	4:15:00	Transit	Transit		
2020-08-07		Kiel	Port		